

AIR WAR COLLEGE

AIR UNIVERSITY

Offsetting Tomorrow's Adversary in a Contested Environment: Defending  
Expeditionary Advance Bases in 2025 and Beyond

By

Branden G Bailey, LtCol, USMC

A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements

Advisor: Dr. Geis

6 April 2017

## **DISCLAIMER**

The views expressed in this academic research paper are those of the author and do not reflect the official policy or position of the U.S. government, the Department of Defense, or Air University. In accordance with Air Force Instruction 51-303, it is not copyrighted, but is the property of the United States government.

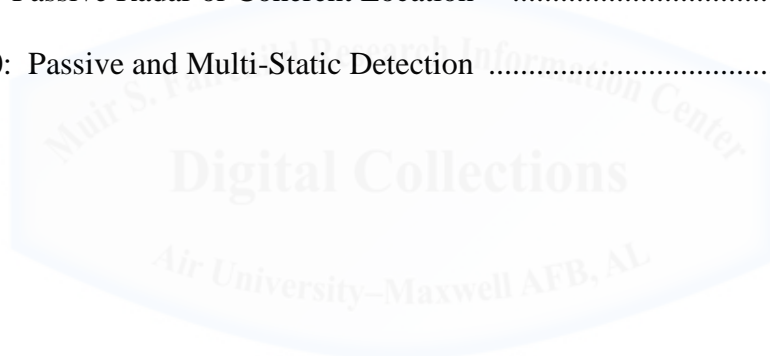


## Table of Contents

<b>DISCLAIMER.....</b>	<b>ii</b>
<b>List of Figures.....</b>	<b>iv</b>
<b>Biography.....</b>	<b>v</b>
<b>Abstract.....</b>	<b>vi</b>
<b>Introduction.....</b>	<b>1</b>
<b>Anti-Access / Aerial Denial .....</b>	<b>2</b>
<b>Innovative Offset Strategy .....</b>	<b>5</b>
<b>Requirement for Joint Solution .....</b>	<b>6</b>
<b>Requirement for Balanced Capabilities Mix.....</b>	<b>6</b>
<b>Expeditionary Advance Basing.....</b>	<b>7</b>
<b>Emerging Technologies .....</b>	<b>10</b>
<b>Directed Energy Weapons.....</b>	<b>11</b>
<b>Autonomy.....</b>	<b>15</b>
<b>Camouflage, Concealment Deception (CCD) and Passive Detection Measures ...</b>	<b>19</b>
<b>Expeditionary Advance Base Defense in Phased Operations .....</b>	<b>21</b>
<b>Findings and Recommendations.....</b>	<b>22</b>
<b>Conclusion .....</b>	<b>24</b>
<b>Bibliography .....</b>	<b>29</b>

## List of Figures

Figure 1: Chinese Missile Capability.....	3
Figure 2: EAB Operations Overview.....	8
Figure 3: GBAD On-the-Move.....	13
Figure 4: Active Denial System .....	14
Figure 5: Silent Archer C-UAS System.....	15
Figure 6: Human Interface "On-the-Loop" .....	16
Figure 7: MDARS .....	17
Figure 8: Wasp Sentry .....	18
Figure 9: Passive Radar or Coherent Location .....	20
Figure 10: Passive and Multi-Static Detection .....	21



## **Biography**

Lieutenant Colonel Bailey is a U.S. Marine Corps aviator assigned to the Air War College, Air University, Maxwell AFB, AL. He holds a Bachelor of Science degree in Psychology from the University of Kansas in Lawrence, KS. LtCol Bailey has amassed over 3300 hours in tactical aviation platforms and has served combat tours in support of Operation Enduring Freedom from the USS Theodore Roosevelt from 2001-2 and support of Operations Iraqi Freedom from Ahmed Al Jaber Air Base, Kuwait in 2003 and Al Asad Air Base, Iraq in 2006-7. Lieutenant Colonel Bailey has served in staff positions at the Group, Wing and MEF levels and has held command at the company and squadron level to include: Commanding Officer Service Company, Headquarters and Service Battalion, Marine Corps Recruit Depot, Parris Island, SC; Commanding Officer Marine Fighter Attack Squadron 533, Marine Corps Air Station, Beaufort SC; and Commanding Officer Marine Aviation Logistics Squadron 31, Marine Corps Air Station, Beaufort, SC. Lieutenant Colonel Bailey's personal awards include the Meritorious Service Medal with Gold Star, Air Medal Individual Action with combat distinguishing device, Air Medal Strike/Flight Award with numeral 12, Navy/Marine Corps Commendation Medal with two gold stars and combat distinguishing device, and the Navy/Marine Corps Achievement Medal.

## **Abstract**

Potential adversaries have studied the operational advantages of the U.S. joint force and as a result are developing A2/AD systems and capabilities intended to challenge the U.S. military's asymmetric advantage by denying freedom of access and maneuver in the global commons and across all warfighting domains. The advancement and proliferation of A2/AD capabilities enable adversaries to negate U.S. high value/capable assets by holding critical forward infrastructure at risk and imposes a cost imposition that could prove prohibitive. Sustained and integrated efforts across the joint force are required to ensure the continued U.S. and allied access to, and maneuver in the global commons. Well defended and mutually supportive Expeditionary Advanced Bases (EABs) will ensure operational freedom of action by keeping a foot in the door in contested environments. The integration of game-changing technology in force development paired with an innovative offset strategy will enhance the joint forces' ability to preserve vital national security interest in contested regions through the employment of well defended EABS supported by a joint force with resilience, capacity, and operational agility.

## Introduction

The rise of potential competitors and proliferating technology present an operational problem to the U.S. Joint Force, which has historically possessed an asymmetric advantage in freedom of access and maneuver through the global commons and has based its operational approaches on this advantage. The National Military Strategy states that the key state actors of Russia, Iran, North Korea and China pose serious concerns to national security interests.<sup>1</sup> Each of these countries has studied the American way of warfighting, understands its requirement for access to global commons and forward basing, and has developed anti-access and area denial capabilities that hold the joint force at risk.

Operating in and maintaining access to contested environments will require the joint force to utilize maneuver from Expeditionary Advance Bases (EABs).<sup>2</sup> Employing multi-domain, task organized and rapidly deployable forces from the EABs will facilitate the conduct of operations in sufficient scale and duration to achieve desired objectives. The defense of EABs calls for the joint force to develop an innovative offset strategy that incorporates emerging technology into operational concepts that ensure freedom of access and maneuver in contested environments.

The U.S. military's asymmetric advantage is built on a technology dependent force that possesses significant capability and efficiency at the risk of reduced quantity and resiliency. Future force development must balance capacity with capability and be informed by an offset strategy that embraces emerging technology to properly counter adversarial anti-access / area denial capabilities in defense of EABs to provide sufficient capacity and resiliency to attain temporal supremacy in a given domain.

## **Anti-Access / Aerial Denial**

The joint force has found itself at a capability versus capacity mismatch due to the growing A2/AD capabilities of rising competitors and must develop an offset strategy that embraces a mix of technologies in defense of EABs. One of the causes of this quandary is that the (or our) joint force has been predominately focused on the defeat of extremist forces that threaten national interests for the last 15 years. Potential adversaries have used this distraction to develop and invest in capabilities that can deter, delay or prevent effective U.S. freedom of access and maneuver within the global commons and threaten the homeland. These threats span all five war-fighting domains (i.e., air, land, sea, space, and cyberspace) and are not unique to one adversary or region of the globe. The proliferation of ballistic missiles, precision strike technologies, unmanned systems, space and cyber capabilities, are of particular concern in defense of forward basing that is required to maintain U.S. military advantages and access to the global commons.<sup>3</sup> China's developing ballistic missile capability is a fundamental element of their A2/AD regional capability and currently puts joint forward basing at risk (see figure 1). While China is often used as the default example, there are significant similarities between the A2/AD strategies and capabilities of our adversaries: they all seek to impose costs on the joint force by using a layered approach that begins with offensive strikes over long ranges and culminates with defenses that increase in intensity with proximity to their homeland. Operational concepts designed to offset adversarial A2/AD capabilities would be similar but have different execution timelines dependent on geographic location.<sup>4</sup>

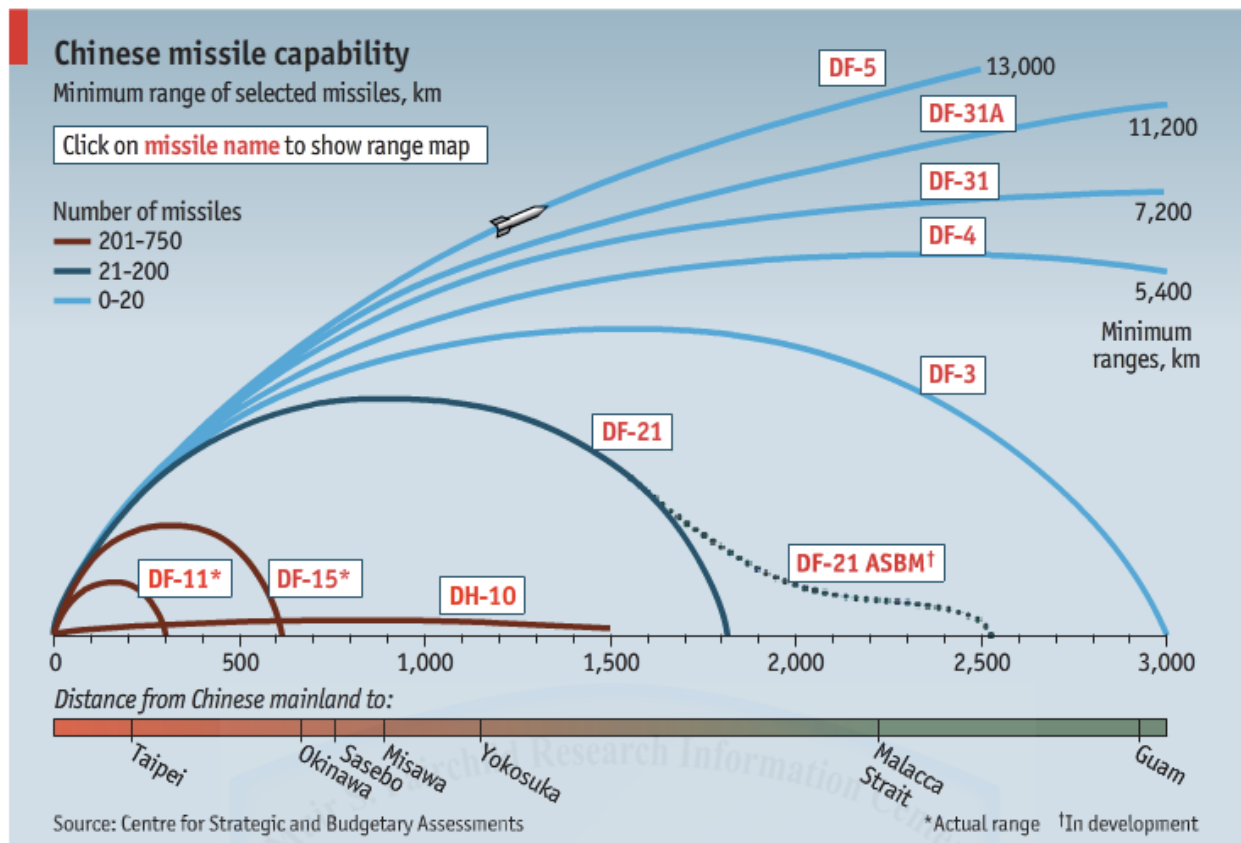


Figure 1: Chinese Missile Capability<sup>5</sup>

The difference between anti-access and area-denial (A2/AD) is sometimes confused and the terms are not interchangeable. As defined in the Joint Operational Access Concept (JOAC) and used in this report, anti-access refers to those actions and capabilities, usually long-range, designed to prevent an opposing force from entering an operational area. Area denial refers to those actions and capabilities, usually of shorter range, designed not to keep an opposing force out, but to limit its freedom of action within the operational area.<sup>6</sup> While operating in a contested environment is not a novel concept, the U.S. has not fought in a truly A2/AD environment in over 60 years.<sup>7</sup> As a result, the U.S. preferred strategy for military action, sometimes coined as the “American Way of War”<sup>8</sup>, is a high intensity, low duration conflict that relies on assured access to all warfighting domains.

Although the “American Way of War” is still dominant in a conventional force on force conflict, rising peer competitors and adversaries are evolving the next paradigm of warfare designed to obviate U.S. global forward basing and expeditionary warfare model. U.S. combat platforms are remarkably capable, but are rendered brittle in a contested environment, by their limited quantity and infrastructure requirements that are highly vulnerable to enemy A2/AD systems.<sup>9</sup> Similar to a modern day “Maginot Line,” the joint forces most valuable capabilities are based in fixed locations that are easily targeted with long-range fires. The essence of the A2/AD challenge is a capability/capacity mismatch with emerging competitors. The underlying strategic/operational requirement to the A2/AD challenge is resiliency.<sup>10</sup> In short, the joint force is far more likely to be overwhelmed than overmatched. To offset this challenge the joint force must take a holistic approach that considers a balance of high-low mix of capability versus capacity that ensures resiliency in a contested environment.

While an adversary’s A2/AD capabilities may deny a particular domain, the U.S. must develop a force that operates simultaneously across multiple domains, leveraging strengths across the strategic environment and compensating for shortfalls in contested areas. Historically, U.S. doctrine has called for the “roll back” of threats within a contested environment. This view encourages a system versus system approach that imposes a significant cost imbalance on the joint force by playing into adversarial A2/AD strengths. This system vs. system approach highlights joint materiel shortfalls that are not fiscally attainable and calls for an offset strategy built on emerging technology that obviates the capacity mismatch. With longstanding allies, treaty obligations, national interests and trading partners situated within the growing arc of potential adversary A2/AD systems, it is imperative that future force development is informed by

an offset strategy that embraces emerging technology to properly counter adversarial A2/AD capabilities in defense of advance bases.

### **Innovative Offset Strategy**

Advancing A2/AD capabilities, and the rise of adversaries possessing them, require new forms of deterrence and concepts of operations in the form of an offset strategy that synergistically links them together.<sup>11</sup> Emerging trends in the strategic operating environment call for an offset strategy that embraces a balanced combination of emerging technology, organizational constructs, and operational innovation. Current strategies and operational approaches are insufficient in countering the adversarial A2/AD threat, which compels the joint force to seek asymmetric advantages that capitalize on its collective strength and exploit adversarial weakness through an offset strategy that blends operational agility, cross-domain synergy, and emerging "game-changing" technologies. The intent of this report is not to define but rather describe what has been coined as the "Third Offset Strategy" and how it directly correlates to the procurement and integration of emerging technology in defense of EABs in a contested environment.

The foundation of an offset strategy to confront A2/AD operating challenges will call for operational approaches that integrate technologies in a complementary vice additive fashion thus compounding their effectiveness and operating with cross-domain synergy by efficiently acting on multiple lines of effort concurrently. This offset strategy will complicate adversarial problems by massing efforts simultaneously in every contested domain to overwhelm the adversary in a combination of efforts, which will enable the joint force to capitalize in a domain that permits the conduct of operations at a given location with sufficient duration to complete the mission.<sup>12</sup> As it has been in the past, technological and operational innovation will be critical in

the formulation of a new offset strategy that will assure the U.S. joint force its asymmetric advantage and the ability to project power in a contested environment with sufficient capacity and resiliency to ensure mission success.

### **Requirement for Joint Solution**

The challenges presented in defense of EABs are compounded by national defense budgetary constraints and calls for force development and operational concepts that combine the strengths and expertise of individual services to complement each other, thus ensuring the holistic power of the joint forces compensates any weakness of a singular service.<sup>13</sup> Future force development must emphasize interoperability amongst all services, across multiple domains, and redundancy in capabilities must be minimized but not at the cost of capacity. Operating concepts must have common tactics, techniques and procedures (TTPs) "baked in" to ensure rapid execution during aggregation of joint forces in defense of EABs.

“Joint synergy has been a strength of U.S. joint forces for decades. Whereas joint synergy focuses on the integration of Service capabilities, cross-domain synergy requires the integration across domains without regard for which Service provides the action or capability.”<sup>14</sup> The level of ‘jointness’ the U.S. military embraces will directly correlate to its cross-domain synergy, the speed it incorporates a high-low mix of emerging technology, and the associated offset strategy needed to defend EABs in a contested environment.

### **Requirement for Balanced Capabilities Mix**

The advancement and proliferation of A2/AD capabilities exploit the U.S. joint forces dependency on critical infrastructure and lack of capacity and resiliency, which calls for a balanced capabilities mix. The U.S. military is a highly capable joint force whose capability is based on costly, but highly technical platforms that are produced in low quantities due to their

exorbitant cost. The U.S. joint force must maintain its ability to defeat the full spectrum of adversarial capabilities without introducing vulnerabilities. To operate decisively in an era calling for leaner budgets and force structure, against adversaries with near technical parity and greater capacity, the joint force must embrace operational agility in future force development, which manifests itself in a balanced capability mix. The term high-low mix describes the intent to procure a reduced number of high-cost/high capability platforms supplemented with an increased number of low-cost/reduced-capability platforms that in turn provide the capacity to balance high-end capability.<sup>15</sup> A balanced capabilities mix provides numerous advantages to the joint force; 1) the capacity to endure a prolonged engagement in an A2/AD environment; 2) the resiliency to absorb losses and continue to press the adversary in multiple domains simultaneously, and 3) interoperability with partner nations and allies that operate low-tech platforms.<sup>16</sup> Implementing a balanced capabilities mix will enable the joint force to meet the capacity and resiliency challenges of defending EABs in a contested environment.

### **Expeditionary Advance Basing**

Expeditionary Advanced Bases (EABs) are an enabling capability designed to operate within the area of adversarial A2/AD threats with a minimal need for fixed infrastructure and operating with the smallest physical and electro-magnetic (EM) footprint, required to accomplish the desired mission. EABs are temporary in nature and to the degree possible use passive defenses and rely upon mobility, mutual support, deception, and concealment to compound the adversary targeting problem (see figure 2). Once an EAB is detected, (e.g. kinetic defensive action, EM/Physical detection, etc.) the "jig is up," and adversaries targeting cycles are completed. EABs enable the dispersal of key assets to cloud adversary targeting process while

providing the joint force proximity to the area of operations and increases offensive options.<sup>17</sup>

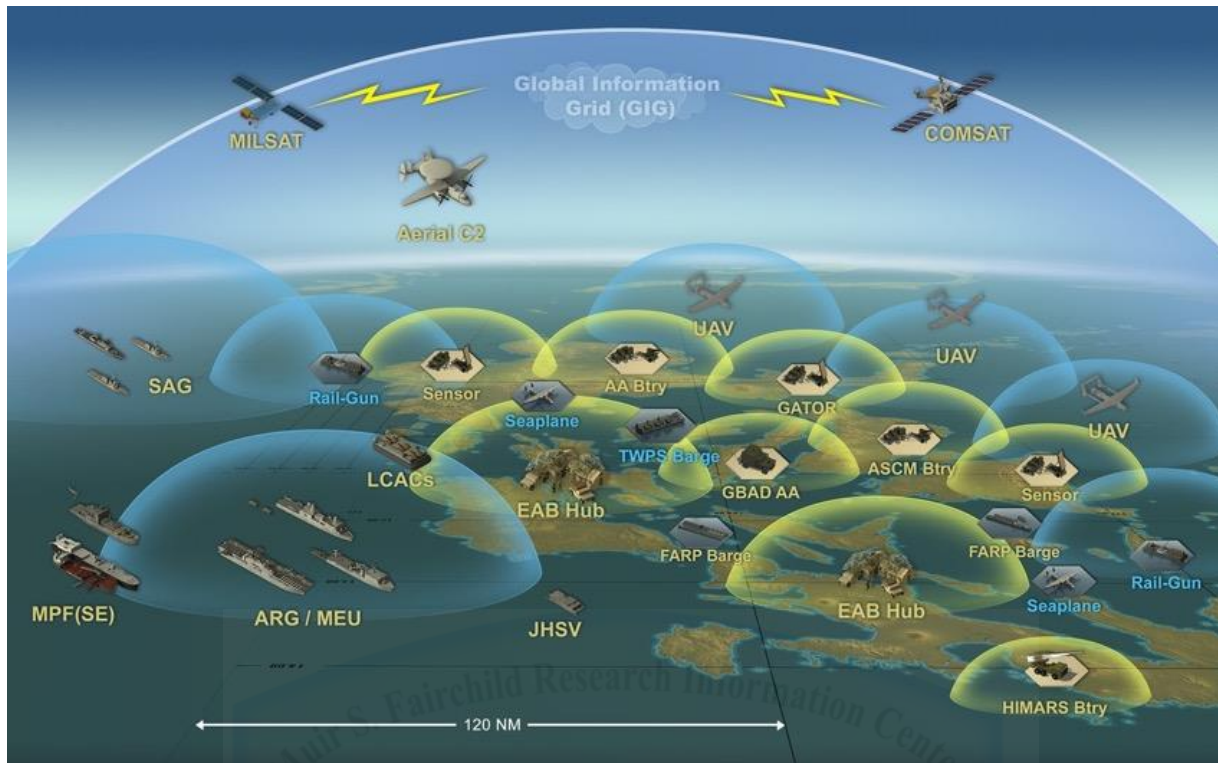


Figure 2: EAB Operations Overview<sup>18</sup>

The use of EABs to offset A2/AD capabilities is not a novel concept, in 1921 the visionary work of then Maj Earl "Pete" Ellis, *"Advanced Base Operations in Micronesia"* provided foresight into what an amphibious campaign in the contested Pacific would require. Concepts from Ellis' work can still be applied when put into the context of the current A2/AD environment that could affect access to the global commons.<sup>19</sup> As we draw lessons from Ellis's work, there are numerous operational concepts across the joint force, that call for some form of EABs or pull from similar technologies and precepts. These lessons highlight the need to more widely distribute bases, develop more resilient capabilities, minimize damage from long range fires and compound the enemy targeting problem as common issues to all services.

EABs operating inside A2/AD arcs will apply significant pressure to an adversary's interior lines and degrade the benefits an adversarial A2/AD technology by changing the

predictive targeting of fixed infrastructure to an uncertain and heavily ISR dependent hidden finder completion. In this sense, EABs can affect a fundamental shift of the cost imposition onto the adversary by compounding the possible targeting requirements for a finite A2/AD arsenal. Beyond complicating targeting, the EABs force in being requires an opponent to react and allocate resources to contend with an “inside force,” essentially holding an enemy force at risk until legacy forces can mass to achieve decision and obviates a fait accompli strategy like that recently seen in the Crimea and Eastern Ukraine.<sup>20</sup> “This gives each Geographic Combatant Commander (GCC) the three-fold advantages of forward presence: the recurring dividends available from “soft power”; deterrence derived from credible and capable response; and the freedom of action created by expanded operational reach and tactical flexibility.”<sup>21</sup>

Additionally, EABs will provide the joint force with economy of force operations in: 1) The offensive capability of one platform at an EAB will free another platform to conduct like capabilities in an alternate location or domain (e.g. a UAS from an EAB can conduct local ISR freeing up another platform to conduct a like mission in another location). 2) Gained efficiencies in shared defenses and logistical support of mutually supportive EABs (see fig 10). 3) The ability to quickly aggregate forces to mass efforts at desired location and time.

EABs are threatened by increasingly complex A2/AD systems threats which make it challenging and costly to conduct and sustain air operations from them.<sup>22</sup> However, the force in being and economy of force that EABs enable will cause an adversary to defend the whole of their territory from credible, yet minimal joint forces located on their periphery, complicating targeting and reversing the cost imposition onto the adversary by compelling him to defend everywhere at once.

The defense of EABs pose significant risk to the GCC which can be reduced with the assimilation of emerging technologies into an offset strategy that addresses a full spectrum of integrated capabilities to counter A2/AD threats and provides integrated joint capabilities, and develops DOTMLPF (Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities) solutions.

## **Emerging Technologies**

Operational approaches, such as the Joint Concept for Access and Maneuver in the Global Commons (JAM-GC), seek to identify capability gaps, provide integrated counter-A2/AD solutions and inform future force development decisions. There are numerous emerging technologies that will directly contribute to the defense of EABs, reducing the risk incurred in their defense and effectively increasing their operational agility. The Air Force Research Laboratory (AFRL) has identified the emerging technologies of Hypersonics, Autonomy, and Directed Energy as possible “game changers” in the implementation of future offset strategies and each lends distinct capabilities in defense of EABs.<sup>23</sup> The technology discussed in this report is illustrative and not meant as a specific recommendation for future force development. The key point to take away is the need for procurement and integration of emerging technology as it becomes viable and relevant to maturing operational approaches, as highlighted in guiding documents like the Joint Strategic Capabilities Plan (JSCP), the Air Force Future Operating Concept (AFFOC), and Expeditionary Forces 21 (EF21). This report will focus specifically on the “game changing” technologies of directed energy and autonomy, as well as developments in camouflage and passive detection that are at a Technology Readiness Level (TRL) of 5 or better and would directly contribute to the defense of EABs in the next 5-10 years.

## **Directed Energy Weapons**

“Exploiting directed-energy technology will provide the opportunity to fundamentally alter operational concepts and support requirements. As we seek flexibility in our weapons effects and the ability to operate in contested environments, directed energy weapons with deep magazines can alleviate the need for acquiring and transporting large stockpiles of munitions into the theater, while providing precise, responsive, and persistent effects.”<sup>24</sup> Emerging nanotechnology has led to the development of advanced battery and capacitors that provides a power source that can charge and discharge rapidly with no decline in performance throughout its life cycle.<sup>25</sup> Near term advancements in this field will provide a viable, cheap and replenishable power source for directed energy weapons and fulfill the power requirements of EABs. Expeditionary fuel-cell generators, power-harvesting techniques (i.e. solar, wind) or the acquisition of local grid power (where possible) will significantly reduce the footprint and logistical requirements of EABs, providing the joint force with highly mobile multi-spectrum defenses with magazines that are only limited by the power available. While the use of directed energy weapons is beneficial to both permanent and expeditionary basing, the use of Low Probability of Detection (LPD) and Low Probability of Intercept (LPI) techniques due to EM signatures must be considered in defense of EABs to not deter from the hide-finder competition.

## **Laser**

The use of solid-state lasers in defense of EABs is possible with current technology that can defeat missile seekers, UAS sensors and defeat soft ground targets. While weather can limit laser effectiveness, the primary threats a laser would counter are affected by the same weather and should not deter further development and incorporation into force development but call for a diverse and layered defense. Increases in power output, tracking capabilities and beam

manipulation have enabled the fielding of laser-based Ground Based Air Defense (GBAD) and counter Guided Rockets, Artillery, Mortars, and Missiles (G-RAMM) technologies that defeat kinetic threats. Expected advancements in technology will further the range and lethality of lasers in defense of EABs. In the next 5-7 years, technology will have integrated 100+ kW High Energy Laser that can defeat threats at moderate range and provide a temporal and spatial defense zone around EABs. In the next 10-15 years, 300+ kW high Energy Lasers that will defeat hard targets in flight and on the ground at stand-off ranges.<sup>26</sup>

Solid-state lasers are ideal for expeditionary use in that they have few moving mechanical parts and consume only electricity, rather than hazardous and caustic chemicals. As such, solid-state lasers are a fraction of the size of chemical lasers, and their weight per power (kg/kW) is about 30 times less, allowing for significant savings in space and weight. Advancements in batteries through nanotechnology have developed supercapacitor batteries that possess rapid discharge/recharge capabilities.<sup>27</sup> These batteries are lighter and do not degrade after multiple charge cycles like current lithium ion batteries which make them highly suitable for expeditionary operations and provide an infinite shot capacity as long as an appropriate power supply is available.

While there are numerous future capabilities for laser technology in defense of EABs, two demonstrators stand as examples, the static Area Defense Anti-Munitions (ADAM)<sup>28</sup> system and the truck mounted GBAD Directed Energy On-the-Move<sup>29</sup> concept demonstrator (see figure 3). Both systems have successfully defeated airborne targets and demonstrated output power up to 30Kw. Both of these platforms show the lethality of a fully integrated solid-state laser weapons system against representative ground-based and surface-to-air targets. Such targets will include rockets, mortars, and surface-to-air missiles and UASs. Key features of the platforms

involve using infrared or optical signals to acquire, track, and hold a precise point on a target, allowing the laser to deliver sufficient energy to disrupt, disable, or destroy it.<sup>30</sup>

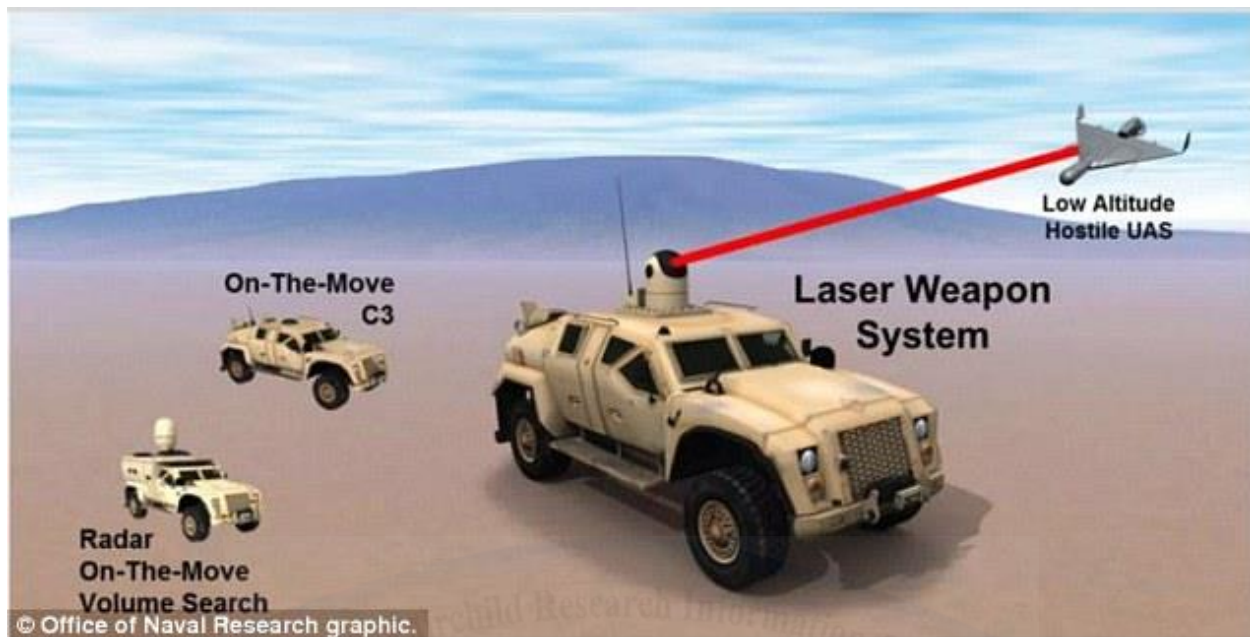


Figure 3: GBAD On-the-Move<sup>31</sup>

## High Power Microwave

High Power Microwave (HPM) technology is an adaptable and proven capability that can aid in defense of EABs through capabilities ranging from area denial to defeating UASs and other electronic systems by emitting highly focused microwave energy upon a target. HPM share similar benefits as laser in that as long as a power source is available they have an unlimited magazine. Additionally, HPM can produce non-kinetic effects that leave infrastructure untouched. Proven HPM technologies are currently fielded, and future advancements in capability will allow for greater effects at range, furthering HPM's ability to defend EABs. Two specific HPW systems that are of particular use in defense of EABs are the Active Denial System (ADS) and Counter-UAS (C-UAS) systems.

The ADS uses focused microwave energy that causes intense pain on targeted individuals at range without resulting in any temporary or permanent physical damage. The non-lethal

millimeter wave penetrates the skin by just a few millimeters and heats the tissue causing a burning sensation.<sup>32</sup> The ADS is capable of static defense that produce effects at greater range due to power output or can be truck mounted allowing it to provide defense at various locations as needed (see figure 4).<sup>33</sup>



*Figure 4: Active Denial System*<sup>34</sup>

In a contested environment, the denial of ISR capabilities is critical to maintaining an adversary's uncertainty and cloud his situational awareness. To this task, the capabilities exemplified by technology like the Silent Archer C-UAS System are essential to the defense of EABs.<sup>35</sup> C-UAS systems can detect, identify, and disrupt UASs individually or in swarms.

These systems are modular, expeditionary and require minimal manning making them a force multiplier (see figure 5).<sup>36</sup>



*Figure 5: Silent Archer C-UAS System<sup>37</sup>*

Directed Energy (DE) weapons are part of a larger set of “game changing” technologies that will provide unprecedented capabilities in defense of EABs. While DE weapons provide a low cost per engagement and continued developments in batteries make them even more expeditionary, their EM signatures must be considered in the hider-finder competition and mitigated with LPI/LPD technology and complemented with other low-cost kinetic abilities to ensure a layered and dense approach is provided in defense of EABs.<sup>38</sup>

### **Autonomy**

Autonomy will enable the joint force exceptional operational agility within a contested environment, enable continuous operations through multiple domains by mitigating A2/AD capabilities and reducing the overall risk in defense of EABs operating under the veil of advanced A2/AD systems.<sup>39</sup> This focus on autonomy in this report is limited to AFRL’s human-machine interface where autonomy provides an asymmetric advantage across a wide spectrum of decision-making, ranging from an information dominant environment to time-dominant environment.<sup>40</sup>

Future autonomous systems must be algorithm vice hardware based and provide the joint force a human-computer interface that presents multi-domain course of action recommendations based on the rapid assessment of the operational environment.<sup>41</sup> The benefits of autonomy will manifest across all domains and result in reduced data-to-decision timelines that will contribute to offset strategies required to ensure continuous operations through contested environments. It is important to note that while it is necessary for autonomous systems to have a degree of self-governance and behaviors to provide the desired effects, there will remain a human interface at critical points ‘on’ the decision-making loop. Having the human interface on the loop at appropriate points enables more cognitive capacity for the human to devote to other tasks allowing the joint force operational agility in domains “where the speed and ubiquity of information makes human processing impractical.”<sup>42</sup> (see figure 6).

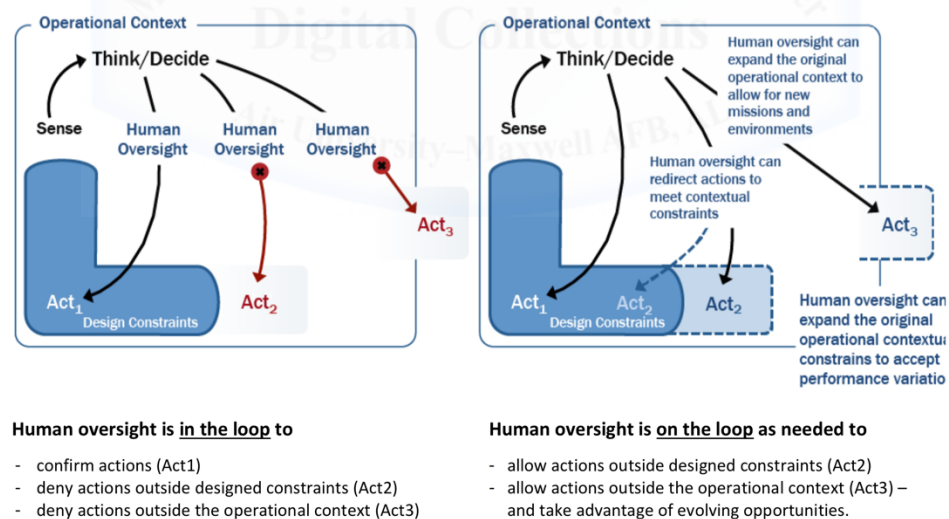


Figure 6: Human Interface "On-the-Loop"<sup>43</sup>

In the future defense of EABs, human-machine teaming capabilities will reduce the overall risk to the joint force by providing physical security through the use of semi-autonomous sentries and UASs. These platforms will autonomously share data to better execute the mission

and only require human interface when an alert is triggered, at which time the system presents the user with multiple courses of action based on the context of the situation and overall operational environment. These efforts will significantly increase the physical security of joint forces in EAB operations by providing persistent force protection in all weather conditions with negligible electromagnetic or physical footprint.

On the ground, expeditionary sentries both static and roaming will be equipped with multi-spectral sensors that can see in all-weather, are networked with tunable ground search radar that can detect man-sized targets outside of 10 miles and wheeled or maritime threats at twice that distance.<sup>44</sup> Roaming sentries will share information and autonomously determine the best routes to provide optimum coverage and re-assess if one platform is no longer mission ready. This current and proven technology is demonstrated by the Mobile Detection Assessment and Response System (MDARS) (see figure 7) and the Wide Area Security Protection (WASP) system (see figure 8). Further development in autonomy will advance the performance and strength of EAB defenses in a VUCA environment.



*Figure 7: MDARS*<sup>45</sup>



*Figure 8: Wasp Sentry*<sup>46</sup>

In the air, future EAB defense is further augmented by autonomous micro-drones that will conduct ISR, and other missions either independently or in swarms. For a fraction of the cost of their larger (and more capable) cousins, these micro-drones can be launched from air, sea or land surrogate platform in proximity to a point of interest and conduct further analysis thus freeing the surrogate platform to continue on mission. This capability is currently resident in the Perdix micro-drone which share a distributed brain for decision-making allowing them to adapt to each other and the operational environment, similar to swarms in nature.<sup>47</sup> Just as with the roaming sentries, the micro-drones collaborate to investigate points of interest, as well as ensure the most efficient execution of the mission and allow graceful degradation in layers of coverage/security. The micro-drones provide a resident ISR capability that will compliment the wide area security of the EAB and provide an additional layer of defense in a contested environment. Future advancement of this technology will lengthen on-station times and expand the missions the micro-drones will fulfill to include EW, Cyber collection, C-UAS through either unitary or Counter-electronics High-powered Microwave Advanced Missile Project (CHAMP)<sup>48</sup> warheads.

Future advancements in autonomy will enhance the defense of EABs by reducing manning requirements for physical security and Processing, Exploitation and Dissemination (PED) personnel needed for defense of the EAB. Future systems will better react to their operational environment and perform context-specific tasks, greatly reducing the data-to-decision loop.<sup>49</sup> Whether through autonomous sentries on the ground, micro-drones in the air, or a collaboration of both, autonomous platforms will provide operational agility in defense of EABs in a contested environment.

### **Camouflage, Concealment Deception (CCD) and Passive Detection Measures**

To maintain the advantage in the hider finder competition, confuse the adversaries operational picture, and ensure the successful defense of EABs the joint force must minimize its physical footprint and overall signature across the Electro Magnetic Spectrum (EMS). The joint force is heavily reliant on the EMS to maintain its asymmetric advantage across multiple domains. To effectively operate in a contested environment, the joint force must develop and employ an offset strategy containing operational approaches adhering to a “low-to-no power EMS regime.” These operational approaches would inform future force development and foster detection capabilities (see figures 9 and 10)<sup>50</sup> by using reflected ambient electromagnetic energy that come from emitters of opportunity to find enemy forces while avoiding detection by their active and passive sensors. By employing enhanced emissions control, Low Probability of Detection (LPD) such as laser/ambient light communications, and Low Probability of Intercept (LPI) such as low-power countermeasures to avoid detection, the joint force will maintain the advantage in the hider finder competition and minimize risk while operating inside enemy A2/AD threats.<sup>51</sup> EABs networked with LPI/LPD communications links and mutually supportive defensive measure will facilitate the conditions for joint force to maintain freedom of

maneuver and the ability to quickly aggregate forces to mass efforts and gain temporal superiority in a given domain. A back to basic approach of camouflage, concealment, and deception with a technical refresh is required for the effective defense of EABs. Advanced types of camouflage are currently available that absorbs/reduce electromagnetic emissions, including visible light, essentially masking camouflaged platforms from multi-spectral sensors.<sup>52</sup> A deliberate focus and re-affirmation of proven concealment techniques paired with the use of deception in all domains will create a false picture of the battlespace for the enemy, greatly enable the defense of EABs and move the advantage towards the joint force in the hider finder competition so prevalent in a contested environment.<sup>53</sup>

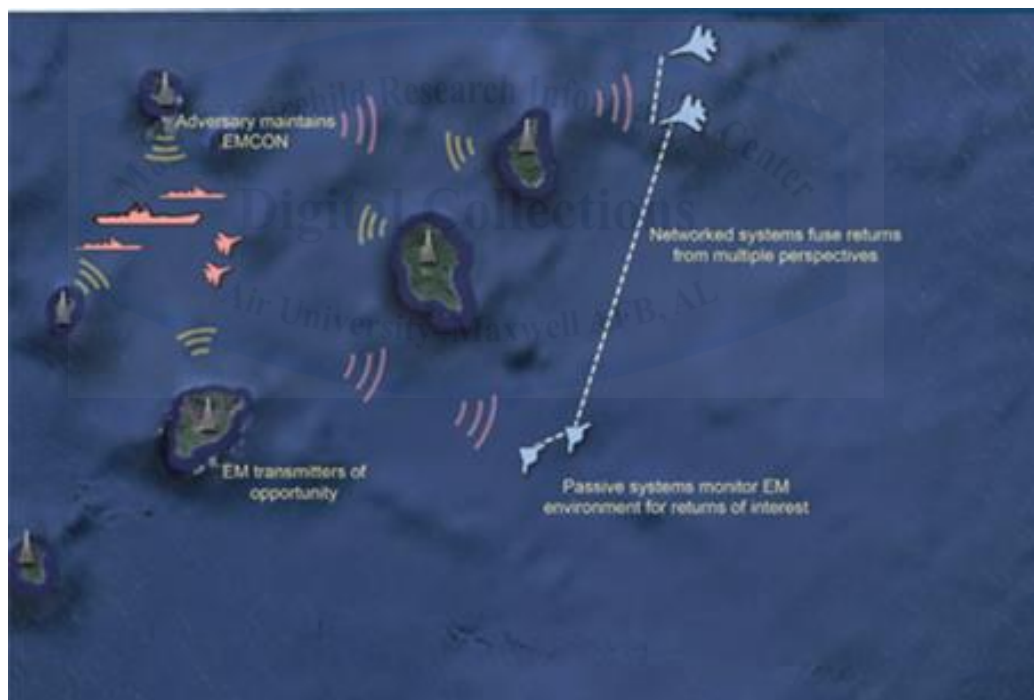


Figure 9: Passive Radar or Coherent Location <sup>54</sup>

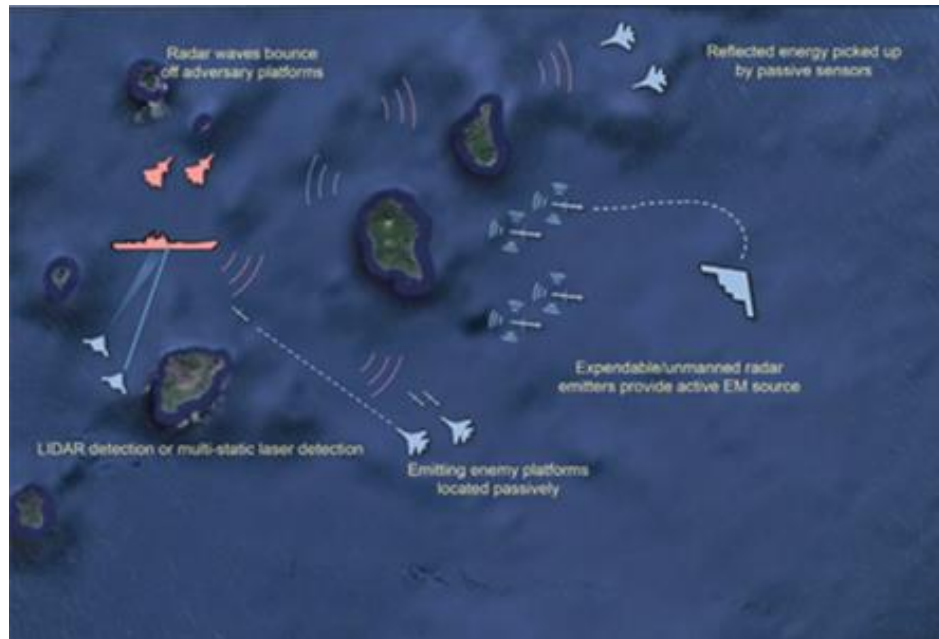


Figure 10: Passive and Multi-Static Detection<sup>55</sup>

## Expeditionary Advance Base Defense in Phased Operations

The operational concepts required and development of the future force needed to effectively offset A2/AD systems in defense of EABs will require forethought and a dedicated effort through all phases of the operational environment.<sup>56</sup> To offset these challenges, the joint force must develop TTPs and procure emerging technologies in a deliberate fashion on a timeline, budget cycle that we control. These efforts will set the conditions facilitate a distributable, resilient, and tailorable force that can deploy in sufficient scale and duration to assure mission success when needed.

Preparations taken during Phase 0 will have a direct and proportional contribution to the successful defense of EABs. The paradigms of operating in a contested environment, while arguably stale, or not novel concepts to the joint force. In his work "Advanced Operations in Micronesia," the then-Maj "Pete" Ellis outlined the requirement for the seizure and defense of advance bases during what is now labeled Phase 0 operations in the prelude to war in the

Pacific.<sup>57</sup> Just as Maj Ellis called for in 1921, the current joint force must set the conditions for future success of EABs. Theater Security Cooperation (TSC) events, joint/bilateral exercises and training detachments to expeditionary sites will ensure interoperability amongst not only the joint force but allied forces as well. During Phase 0 operations the joint force must identify and build enduring infrastructure in support of EABs (e.g. Forward Arming and Refueling Point sites, shore power, and highway/expeditionary runways), enhance partnerships, inform force development and operational approaches, and most importantly maintain access to possible EAB locations. The success and frequency of Phase 0 operations will directly contribute to the deterrence of Phase 1 operations. TSCs and other Phase 0 events enable the joint force to hold a “foot in the door” through force in being, which will preclude or minimize force required if later entry operations were needed to “kick in the door.” The joint forces’ presence and use of EABs in Phase 0 operations is a deterrent of itself and promotes operational resiliency by changing the adversaries targeting problem from predictive to time sensitive, increases survivability by dispersing the force and shifts cost imposition onto the adversary by having to defend everywhere at once. Deliberate operational concept and future force development will ensure the capacity to seize the initiative in Phase 2 and the resiliency to dominate through persistence in Phase 3 operations.

## **Findings and Recommendations**

Rapid development in A2/AD capabilities and the rise of potential adversaries possessing them requires an innovative offset strategy that incorporates force development with balanced capabilities and operational approaches needed in defense of EABs. The joint force must conduct an analysis of alternatives, through the holding of wargames and simulation, to determine the trade space in the best combination of technologies and the organizational

constructs to achieve the required operational agility to maintain access and maneuver in a contested environment. A balance in high-low technology is possible through a cognizant assertion to not lose resiliency at the cost of efficiency, or capacity at the cost of technological capability in the development of the future force. The foundation of adversarial A2/AD systems is built on capacity that outlasts the joint forces technical capability, U.S. future force development must not follow the same track that brought us here. Guiding documents ranging from the Joint Strategic Capabilities Plan (JSCP) to the Air Force Future Operating Concept (AFFOC), informed by operational approaches like JAM-GC and Inside-Out, call for the procurement and implementation of emerging technology in defense of EABs, they must be adhered too. A partial list of implications for force development from the AFFOC calls for:

- “-Tailored forward presence from small, resilient bases, using dispersal, warning, active and passive defenses, rapid repair capabilities, and streamlined logistics through the use of additive manufacturing.
- Algorithm-based (as opposed to hardware based) human-computer interface systems
- Strong, mutually-beneficial partnerships with an array of joint, interagency, multinational, academic and commercial entities.”<sup>58</sup>

The AFFOCs call for integration of emerging technology is paramount in the joint forces ability to maintain an asymmetric advantage against future adversaries in defense of EABs.

A key point that must ring true in the future force development is the requirement for a balanced capabilities mix. In implementing a high-low technology mix with a limited budget, we must guard against the joint forces infatuation with technology and the insatiable desire to increase capability at the expense of capacity and resiliency, in this case “quantity has a quality

all its own.” The last 20 percent of technology development results in 80 percent of procurement costs. For the low-technology platforms, the 80 percent solution is good enough.<sup>59</sup> As an example, the F-18 was intended to provide a capacity balance to the capability of the F-14. The initial cost of \$5m rose to \$20m apiece after numerous capabilities were added during force procurement, resulting in a costly high/high capability mix.<sup>60</sup> For the JSCP and AFFOC to meet the challenges of the future, they must adhere to their own guidance.

## **Conclusion**

Potential adversaries have studied the operational advantages of the U.S. joint force and as a result are developing A2/AD systems and other capabilities intended to challenge the U.S. military’s asymmetric advantage by denying freedom of access and maneuver in the global commons and across all warfighting domains. The advancement and proliferation of A2/AD capabilities enable adversaries to negate U.S. high value/capable assets by holding critical forward infrastructure at risk and imposes a cost imposition that could prove prohibitive. Sustained and integrated efforts across the joint force are required to ensure the continued U.S. and allied access to, and maneuver in the global commons. Well defended and mutually supportive EABs will ensure operational freedom of action by keeping a foot in the door of contested environments. The thesis presented in this report argues that the integration of game-changing technology in force development paired with an innovative offset strategy will enhance the joint forces’ ability to preserve vital national security interest and meet US treaty and legal obligations in contested regions through the employment of well defended EABS supported by a joint force with resilience, capacity, and operational agility.

Operational concepts such as JAM-GC and Outside-In will inform decision makers on the emerging technologies and offset strategies needed to counter adversarial A2/AD capabilities

in defense of EABs and create a more favorable cost-exchange ratio for the joint force.<sup>61</sup> These efforts will enable the U.S. military, through the economy of force and force in being that EABs offer, the ability to hold adversaries at risk until legacy forces can mass to achieve decision within a contested environment.



---

## Endnotes

<sup>1</sup> Dunford, Chairman's Foreword to The National Military Strategy of the United States of America 2017, 1.

<sup>2</sup> The Joint Chiefs of Staff (JCS), Joint Operational Access Concept (JOAC), 7-8. Corbett, Expeditionary Advanced Base Operations: Considerations for Force Development, 3.

<sup>3</sup> The Joint Chiefs of Staff, The National Military Strategy of the United States of America 2015, 3.

<sup>4</sup> Gunzinger, Outside-In: Operating from Range to Defeat Iran's Anti-Access and Area-Denial Threats, 23.

<sup>5</sup> Chinese missile capability graphic downloaded from economist.com online article China's missiles.

<sup>6</sup> The Joint Chiefs of Staff (JCS), Joint Operational Access Concept (JOAC), i.

<sup>7</sup> Van Tol, AirSea Battle, 23.

<sup>8</sup> Ibid, 2.

<sup>9</sup> Corbett, Expeditionary Advanced Base Operations, 4.

<sup>10</sup> Corbett, Expeditionary Advanced Base Operations, 1. Covers previous two sentences.

<sup>11</sup> McGregor, MAGTF Distributed STOVL Operations (DSO), Slide presentation.

<sup>12</sup> JCS, JOAC, 14.

<sup>13</sup> JCS, JOAC, 16.

<sup>14</sup> Ibid.

<sup>15</sup> James & Welsh III, Air Force Future Operating Concept (AFFOC), 10. Covers previous two sentences.

<sup>16</sup> James & Welsh III, AFFOC, 10.

<sup>17</sup> Corbett, EAB Operations, 6. Previous two sentences.

<sup>18</sup> Marine Corps Warfighting Lab, Expeditionary Advance Base Operations Wargame Toolkit & Future Options, 3.

<sup>19</sup> Aiken, Revisiting Advanced Base Operations, 31-34.

<sup>20</sup> Corbett, Expeditionary Advance Base Operations, 3.

<sup>21</sup> Amos, EF21, 16.

<sup>22</sup> United States Air Force, Air Force Strategic Environment Assessment 2014-2034 (AFSEA), 24.

<sup>23</sup> Stone, Air Force S&T: Empowering You for Global Vigilance – Global Reach – Global Power, slide 26.

- 
- <sup>24</sup> James & Welsh III, AAF, 18.
- <sup>25</sup> University of Central Florida, Nano Engineers produce a Battery Alternative, 1.
- <sup>26</sup> Stone, Slide 28. Entire paragraph derived from this source.
- <sup>27</sup> University of Central Florida, Nano Engineers produce a Battery Alternative, 1.
- <sup>28</sup> Area Defense Anti-Munitions (ADAM) Fact Sheet, (Martin n.d.)<http://www.lockheedmartin.com/us/products/ADAM.html>.
- <sup>29</sup> GBAD On-the-Move fact sheet, <https://www.onr.navy.mil/~media/Files/Fact-Sheets/30/GBAD.ashx>.
- <sup>30</sup> Ibid.
- <sup>31</sup> Ibid.
- <sup>32</sup> Air Force Research Laboratory, Directed Energy Fact Sheet.
- <sup>33</sup> Ibid.
- <sup>34</sup> AFRL Directed Energy Fact Sheet.
- <sup>35</sup> SCR Inc, Silent Archer Fact Sheet, <http://www.srcinc.com/what-we-do/ew/silent-archer-counter-uas.html>.
- <sup>36</sup> Ibid.
- <sup>37</sup> Ibid.
- <sup>38</sup> Derived from notes collected during AFRL Directed Energy Directorate site visit on 20 Sep 2016.
- <sup>39</sup> Stone, Slide 29.
- <sup>40</sup> Linn, Autonomy Initiative Overview: RY Contributions 4 Aug 2016.
- <sup>41</sup> James & Welsh III, AFFOC, 36.
- <sup>42</sup> James & Welsh III, AFFOC, 24.
- <sup>43</sup> Defense Science Board, Summer Study on Autonomy, 14-19.
- <sup>44</sup> Wide Area Surveillance & Protection (WASP) Fact Sheet, <http://www.iecifrared.com>.
- <sup>45</sup> Shoop, et al., Mobile Detection Assessment and Response Systems (MDARS): A Force Protection, Physical Security Operational Success.
- <sup>46</sup> Wide Area Surveillance & Protection (WASP) Fact Sheet, <http://www.iecifrared.com>.
- <sup>47</sup> Perdix Fact Sheet covers previous two sentences.  
<https://www.defense.gov/Portals/1/Documents/pubs/Perdix%20Fact%20Sheet.pdf>.
- <sup>48</sup> Air Force Research Laboratory, High Power Electromagnetics Fact Sheet.  
[http://www.kirtland.af.mil/afrl\\_rd/index.asp](http://www.kirtland.af.mil/afrl_rd/index.asp)
- <sup>49</sup> Linn, Autonomy Initiative, slide 2.
- <sup>50</sup> Gunzinger & Clark, Winning the Airwaves: Regaining America's Dominance in the Electromagnetic Spectrum, 20-21.

---

<sup>51</sup> Gunzinger & Clark, *Winning the Airwaves: Regaining America's Dominance in the Electromagnetic Spectrum*, iii. \*\*1 According to DoD, a multi-static radar is a "radar system with a transmitter and several receivers, all separated. An advantage of multi-static radar over monostatic radar [a radar with a co-located transmitter and receiver] is that even if transmitters, which might be detected by the enemy when operating, are attacked, receivers in other locations might not be noticed and might thereby escape attack." Department of Defense, *Ballistic Missile Defense Glossary* (Washington, DC: Ballistic Missile Defense Organization, June 1997), p. 189

<sup>52</sup> ADAPTIV Fact Sheet. <http://www.baesystems.com/en/feature/adativ-cloak-of-invisibility>

<sup>53</sup> Gunzinger & Clark, *Winning the Airwaves*, 21

<sup>54</sup> Gunzinger & Clark, *Winning the Airwaves: Regaining America's Dominance in the Electromagnetic Spectrum*, 20-21.

<sup>55</sup> Ibid.

<sup>56</sup> Amos, *Expeditionary Force 21, Forward and Ready: Now and in the Future*, 16.

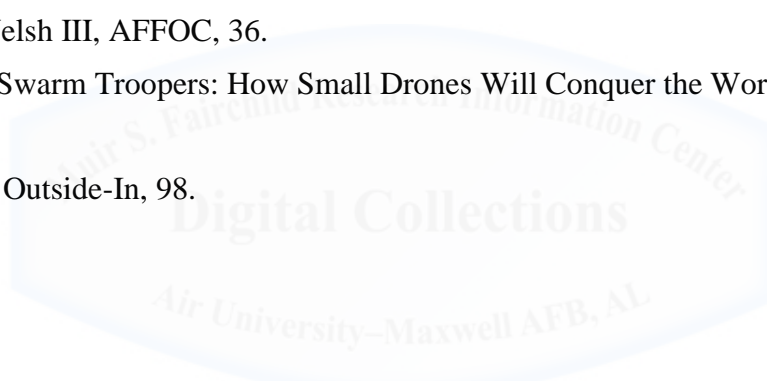
<sup>57</sup> Aiken, *Revisiting Advance Base Operations*, 31.

<sup>58</sup> James & Welsh III, *AFFOC*, 36.

<sup>59</sup> Hambling, *Swarm Troopers: How Small Drones Will Conquer the World*, 95.

<sup>60</sup> Ibid, 92.

<sup>61</sup> Gunzinger, *Outside-In*, 98.



## Bibliography

- (MCWL), Marine Corp Warfighting Laboratory. June 2016. *Epeditionary Advance Base Operations: Wargame Tollkit & Future Options*. Wargame Toolkit, Quantico: HQMC, Marine Corps Warfighting Laboratory.
- (RD), Air Force Reasearch Laboratory. 2015. "Air Force Reasearch Laboratory Directed Energy Fact Sheet." *Air Force Reasearch Laboratory website*. April 24. Accessed Dec 5, 2016. <http://www.de.afrl.af.mil/pa/factsheets>.
- Aiken, Scott D. 2014. "Revisting Advanced Base Operations." *Marine Corps Gazzete* 98 (3): 31-34.
- Amos, James E. 2014. "Expeditionary Force 21." *Expeditionary Force 21, Forward and Ready: Now and in the Future*. Washington, DC: HQ USMC, March 4.
- Board, Defense Science. June 2016. *Summer Study On Autonomy*. Study, Washington: Department of Defense.
- Board, Defense Science. n.d. *Summer Study on Autonomy June 2016*. Science, Washington, DC: DoD.
- Brian Shoop, Michael Johnson, Richard Goehring, John Moneyhun, Brian Skibba. 2007. *Mobile Detection Assessment and Response Systems (MDARS): A Force Protection, Physical Security Operational Success*. MDARS, San Diego: Space and Naval Warfare Sytems Center.
- Corbett, Art. 2016. *Expeditionary Advanced Base Operations: Considerations For Force Development*. Information, unpublished.
- Economist, The. 2010. "The Economist." *The Economist Online*. Dec 6. Accessed Dec 20, 2016. [http://www.economist.com/blogs/dailychart/2010/12/chinese\\_missile\\_ranges](http://www.economist.com/blogs/dailychart/2010/12/chinese_missile_ranges).
- Florida, University of Central. n.d. *Nanoengineers produce a battery alternative* . Accessed Nov 29, 2016.
- Force, United States Air. 2014. *U.S. Air Force Strategic Environment Assessment 2014-2034*. United States Air Force.
- Gunzinger, Bryan Clark and Mark. 2015. *WINNING THE AIRWAVES REGAINING AMERICA'S DOMINANCE IN THE ELECTROMAGNETIC SPECTRUM*. Science, Washington, DC: CENTER FOR STRATEGIC AND BUDGETARY ASSESSMENTS.
- Gunzinger, Byan Clark and Mark. 2015. *Winning the Airwaves: Regaining America's Dominance in the Electromagnetic Spectrum*. Washington: Center for Strategic Budgetary Assessments.
- Gunzinger, Mark. 2011. *Outside-In: Operating from Range to Defeat Iran's Anti-Accesss and Area-Denaial Threats*. CSBA Report, Washington: Center for Strategic and Budgetary Assessments.
- Hambling, David. 2015. *Swarm Troopers: How Small Drones will Conquer the World*. N/A: Archangel Ink.

- III, Deborah Lee James & Mark A Welsh. Sept, 2015. *Air Force Future Operating Concept, a View of the Air Force in 2035*. Washington, DC: Department of the U.S. Air Force.
- Jan Van Tol, Mark Dunzinger, Andrew Krepinevich, Jima Thomas. 2010. "AirSea-Battle." *csbaonline*. May 18. Accessed Dec 07, 2016.  
<http://csbaonline.org/uploads/documents/2010.05.18-AirSea-Battle.pdf>.
- Laboratory, Air Force Research. 2016. "The Air Force Research Laboratory ." *AFRL Directed Energy Directorate*. December. Accessed December 20, 2016.  
[http://www.kirtland.af.mil/afrl\\_rd/index.asp](http://www.kirtland.af.mil/afrl_rd/index.asp).
- Laboratories, Air Force Research. 2016. *Air Force S&T: Empowering You for Global Vigilance - Global Reach - Global Power*. Performed by Dr. Morley O. Stone. Jones Auditorium, The Air War College, Maxwell AFB. December 5.
- Laboratories, Air Force Research. 2016. *High Energy Laser Discussion*. Performed by Francesco Echeuerria. AFRL Site Visit, Kirkland AFB. September 20.
- Lang, Katie. 2016. "DoD Live." *DoD Live*. March 30. Accessed Dec 15, 2016.  
<http://www.dodlive.mil/?s=third+offset+strategy>.
- Linn, Aaron. 2016. *Autonomy Initiative Overview: RY Contributions 4 Aug 2016*. PDF, Dayton: Air Force Research Laboratory.
- Mark A Welsh III, Deborah Lee James. July, 2014. *America's Air Force: A Call to the Future*. PDF, Washington, DC: Department of the U.S. Air Force.
- Martin, Lockheed. n.d. "lockheedmartin.com." *Area Defense Anti-Munitions (ADAM)*. Accessed Dec 20, 2016. <http://www.lockheedmartin.com/us/products/ADAM.html>.
- McGregor, Brett. n.d. *MAGTF Distributed STOVL Operations (DSO)*. Slide Presentation, F-35 Plans, HQMC AVN APP-53, HQMC: Unpublished.
- Micheal Hutchens, William Dries, Jason Perdew, Vincent Bryant, and Kerry Moores. 2016. *JAM-GC, A New Joint Operational Concept: Built on the Air-Sea "Chassis"*. pre-decisional , Washington : unpublished.
- Montgomery, Mark L. 2016. "Expeditionary Force 21." *Marine Corps Gazette* 115-118.
- Office, Strategic Capabilities. n.d. "Perdix Fact Sheet." *Defense.gov*. Accessed Dec 20, 2016. <https://www.defense.gov/Portals/1/Documents/pubs/Perdix%20Fact%20Sheet.pdf>.
- Purcell, Richard. 2014. "AirSea Battle: An Evaluation." *Security Dilemmas*. October 16. Accessed December 7, 2016. [http](http://).
- Research, Office of Naval. n.d. "onr.navy.mil." *Ground-based Air Defense Energy On-the-Move*. Accessed Dec 20, 2016. <https://www.onr.navy.mil/~media/Files/Fact-Sheets/30/GBAD.ashx>.
- Staff. 2015. "Defense-Update." *defense-update.com*. May 16. Accessed December 20, 2016. [http://defense-update.com/20150516\\_champ.html#.VijFhdadLzl](http://defense-update.com/20150516_champ.html#.VijFhdadLzl).
- Staff, The Joint Chiefs of. 2012. *Joint Operational Access Concept Version 1.0, 17 January 2012*. JOAC, Washington: Department of Defense.

- Staff, The Joint Chiefs of. 2015. *The National Military Strategy of the United States of America*. NMS, Washington: The Department of Defense.
- Systems, BAE. n.d. "BAE Systems ." *ADAPTIV - Cloak if Invisibilty*. Accessed Feb 17, 2017. <http://www.baesystems.com/en/feature/adativ-cloak-of-invisibility>.
- Systems, IEC Infrared. n.d. "Mobile Mitigator - WideArea Surveillance & Protection (WASP) Fact Sheet." *iecifrared.com*. Accessed Dec 20, 2016. <http://www.iecifrared.com>.
- Weigly, Russell F. 1973. *The American Way of War: A History of the United States Military Strategy and Policy*. Indiana University Press.

